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Epidemiology of Malaria Cases in India: A Statistical Analysis

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Authors' contributions

This work was carried out in collaboration between both authors. Author SH did the study design and did the literature searches. Statistical analysis, writing the protocol and analyses of study was done by author PK. Both authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

In this paper we studied the state-wise patterns of transmissibility of prevalence of malaria epidemic in India, using yearly time series data for the period 2001 to 2013. The data for the study was obtained from different reports of National Vector Borne Disease Control Programme (NVBDCP), Ministry of Health and Family Welfare, Government of India. The time series data was initially analyzed by using the Confidence Interval and Chi square tests. We have also used the Analysis of Variance (ANOVA) and a post hoc Tukey HSD tests to analyze the geographical differences between means of prevalence rate of malaria.

The result of the study reveals that prevalence rate of malaria shows a decreasing trend for the study period from 2001 to 2013 in India. Further, ANOVA test has shown a significant difference between the prevalence rates of malaria across different states in India, even though a decreasing trend was noted over the study period from 2008 -2013. Also eight homogenous subgroups were

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formed by using post hoc Tukey HSD test, in which four states viz. Mizoram, D & N Haveli, Arunachal Pradesh and Meghalaya had the highest prevalence of malaria as compared to other states of India; Delhi, Bihar, Himachal Pradesh, Kerala, Jammu & Kashmir, Lakshadweep, Sikkim, Punjab, Puducherry and Uttarakhand had the lowest prevalence rate. The results of this study can be of critical importance as different authors attempt to explore novel approaches to investigate the geographic variation in disease occurrence.

Keywords: Prevalence rate of malaria; ANOVA tests; Tukey HSD tests and topography.

1. INTRODUCTION

Malaria is a life-threatening disease caused by parasites that are transmitted to people through the bites of infected mosquitoes. Approximately half of the world's population is at risk of malaria. Most malaria cases and deaths occur in sub-Saharan Africa. However, Asia, Latin America, and to a lesser extent the Middle East and parts of Europe are also affected. In 2014, 97 countries and territories had ongoing malaria transmission. According to the latest estimates, released in December 2014, there were about 198 million cases of malaria in 2013 and an estimated 0.58 million deaths [1].

In the South East Asia Region approximately 337 million population are at moderate to high risk of Malaria [2]. According to the World Malaria report 2014, it is estimated that the number of confirmed malaria cases reported in the South-East Asia Region (SEAR) decreased from 2.9 to 1.5 million between 2000 and 2013. Three countries accounted for 97% of cases in 2013: India (55%), Myanmar (21%) and Indonesia (21%) [3].

In India, about 95% population resides in malaria endemic areas and 80% of malaria reported in the country is confined to areas consisting 20% of population residing in tribal, hilly, difficult and inaccessible areas [4]. During 2011, the malaria incidence was around 1.31 million cases, 0.67 million *Plasmodium falciparum* (Pf) cases and 754 deaths; while during 2012, 1.01 million cases, 0.53 million Pf cases and 519 deaths were reported. About 91% of malaria cases and 99% of deaths due to malaria are reported from high disease burden states namely North-Eastern (NE) States, Andhra Pradesh, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and West Bengal. However, other states are also vulnerable and have local and focal upsurge [5].

Extensive literature search looking at trend of Malaria prevalence revealed limited number studies being conducted in India, hence, evidence has been gathered from the studies done mainly in the African region. In Kola Diba of Northwest Ethiopia, the highest peak of malaria cases was seen during spring seasons of the year [6]. Geographic information systems in combination with historical maps were used to quantify the anthropogenic impact on the distribution of malaria in the 20th century at six intervals between 1900 and 2002. Stratifying the present day malaria extent by endemicity class and examining regional differences highlighted that nearly 1 billion people are exposed to hypoendemic and mesoendemic malaria in Southeast Asia [7].

In India the disability adjusted life years lost due to malaria were 1.86 million years and Cost–benefit analysis suggested that every Rupee invested by the National Malaria Control Program paid a rich dividend of 19.7 Rupees [8]. Hence effective implementation of the preventive strategies can bring the burden not only in-terms of the prevalence of Malaria but also the costs involved in the programme. Evidence from scientific literature regarding the trend of malaria burden remains lacking in India. Hence the present study attempts to add to existing body of knowledge of Malaria, its trend and possible methods of trend analysis in India.

2. MATERIALS AND METHODS

This study was carried out by using secondary data of Malaria cases and deaths across different States of India. Thirteen year (2001 – 2013) malaria cases data was obtained from successive annual reports of National Vector Borne Disease Control Programme (NVBDCP), Ministry of Health and family welfare, Government of India and the data of total population of India and the states was obtained from National Commission on Population, Ministry of Health and Family Welfare [5,9]. This study examined records of 20,728,060 malaria cases registered over thirteen years (2001 – 2013) in India. The period for the analysis has been dictated by the availability of data at

country level and related to the length of time series. The data present in the electronic format was abstracted from the Microsoft Excel database and imported into SPSS statistical software and analyzed using different statistical methods such as confidence interval (CL), and Analysis of Variance (ANOVA).

3. RESULTS AND DISCUSSION

Malaria is a huge public health problem in terms of morbidity and burden on health care facilities in India. In the present study fluctuating trend of Malaria was observed during study period of 2001-2013. A total of 20,728,060 confirmed cases of Malaria were reported in India. Cases of Malaria were found to be decreasing within the study period and very less number of cases reported (836,916) in 2013; highest number of cases (2,085,484) being reported in 2001. Out of these total 20,728,060 confirmed malaria cases, 12,760 persons died during the study period, with a mean of 981 per year. In the present study we also observed a fluctuating trend of deaths of malaria cases within the study with the minimum (359) in 2013 and maximum (1,707) in 2006 (Fig. 1). The proportion of *Plasmodium vivax* and *Plasmodium falciparum* varied in different parts of India. The increasing trend of total malaria cases was seen mainly due to an increase of P. falciparum with a minor contribution of *Plasmodium vivax*.

The prevalence of malaria is calculated by measuring the presence of malaria in a sample of the population selected randomly, then dividing the number of cases of malaria by the total population. Table 1 shows that the prevalence rate of malaria decreased from 0.2027% (CL 0.2024 – 0.2030) in 2001 to 0.0684% (CL 00683 – 0.0685) in 2013. A decreasing trend was noted from 0.2027% (CL 0.2024 – 0.2030) in 2001 to 0.1760 % (CL 0.1757 – 0.1762) in 2003 with a slight increase in 2004 where it was increased to 0.1775% (CL 0.1772 – 0.1777). Further, from 2005 onwards it gradually decreased from 0.1658 (CL 0.1655 – 1660) to 0.0684% (CL 0.0683 – 0.0685) in 2013 (Table 1). The same trend was observed in two Indian studies [10,11]. Also the year-wise deaths due to malaria were tested by using the Chi-square tests and the results show that there was a significant difference between number of deaths and survivors in India.

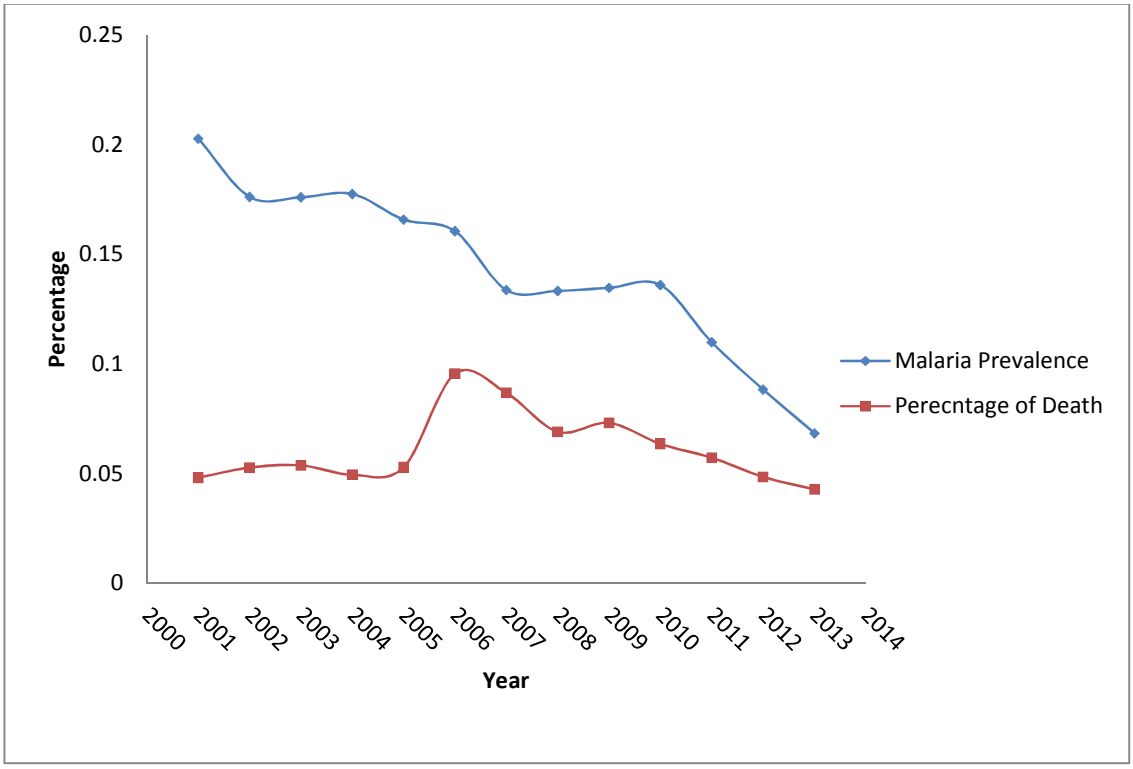


Fig. 1. Trend of malaria prevalence and percentage of death due to malaria, India, 2001 - 2013

Table 1. Year-wise distribution of prevalence rate of Malaria in India for the period 2001 to 2013

Year	Total population	Number of malaria cases	Prevalence rate of malaria	95% CL
2001	1028737436	2085484	0.2027	(0.2024-0.2030)
2002	1045547000	1842019	0.1762	(0.1759-0.1764)
2003	1062388000	1869403	0.1760	(0.1757-0.1762)
2004	1079117000	1915363	0.1775	(0.1772-0.1777)
2005	1095722000	1816569	0.1658	(0.1655-0.1660)
2006	1112186000	1785129	0.1605	(0.1603-0.1607)
2007	1128521000	1508927	0.1337	(0.1335-0.1339)
2008	1144734000	1526210	0.1333	(0.1331-0.1335)
2009	1160813000	1563574	0.1347	(0.1345-0.1349)
2010	1176742000	1599986	0.1360	(0.1358-0.1362)
2011	1192506000	1310656	0.1099	(0.1097-0.1101)
2012	1208116000	1067824	0.0884	(0.0882-0.0886)
2013	1223581000	836916	0.0684	(0.0683-0.0685)

3.1 State-wise Distribution of Malaria Cases in India

The state-wise prevalence rate of malaria cases is shown that six states viz. Megalaya, Arunachal Pradesh, Dadar & Nagar Haveli, Mizoram and Orissa are having higher prevalence rates of malaria than others in India. Further it is observed that in almost all the states the prevalence rate of malaria was decreasing for the study period. Because early diagnosis and complete treatment, integrated vector control including promotion of Insecticide Treated Bed Net (Long-Lasting Insecticidal Nets), through intensive IEC and capacity building, training of the health workers and community volunteers has been the backbone of malaria control in India. The control of urban malaria depends primarily on the implementation of urban bye-laws to prevent mosquito breeding in domestic and peri-domestic areas or residential blocks and government/commercial buildings, construction sites. The Bye-laws have been enacted and being implemented in Delhi, Chennai, Mumbai, Chandigarh, Ahmedabad, Bhavnagar, Surat, Rajkot, Bhopal, Agartala and Goa etc. [3].

In order to carry out deeper analysis of the preceding results and derive more meaningful conclusion, we intended to study the state-wise prevalence rate of malaria. The one-way ANOVA was applied to verify whether the prevalence rate of malaria was unequally distributed between the states. Before applying the One-way ANOVA, we needed to test the assumptions underlying the one-way ANOVA. There are three assumptions i.e. independence, normality and homogeneity. In this study the assumption of independence and normality were satisfied, since the testing centers of states were independent of each other, but the assumption of homogeneity of variance was not satisfied. If a statistical procedure is minutely affected by violating an assumption, the procedure is said to be robust with respect to that assumption. The One-way ANOVA is robust with respect to violations of the assumptions, except in the case of unequal variances with unequal sample sizes. That is, the ANOVA can be used when variances are only approximately equal if the number of subjects in each group is equal and since we have equal sample sizes for all the groups we can assume that variances are approximately equal and proceed with one-way ANOVA [12].

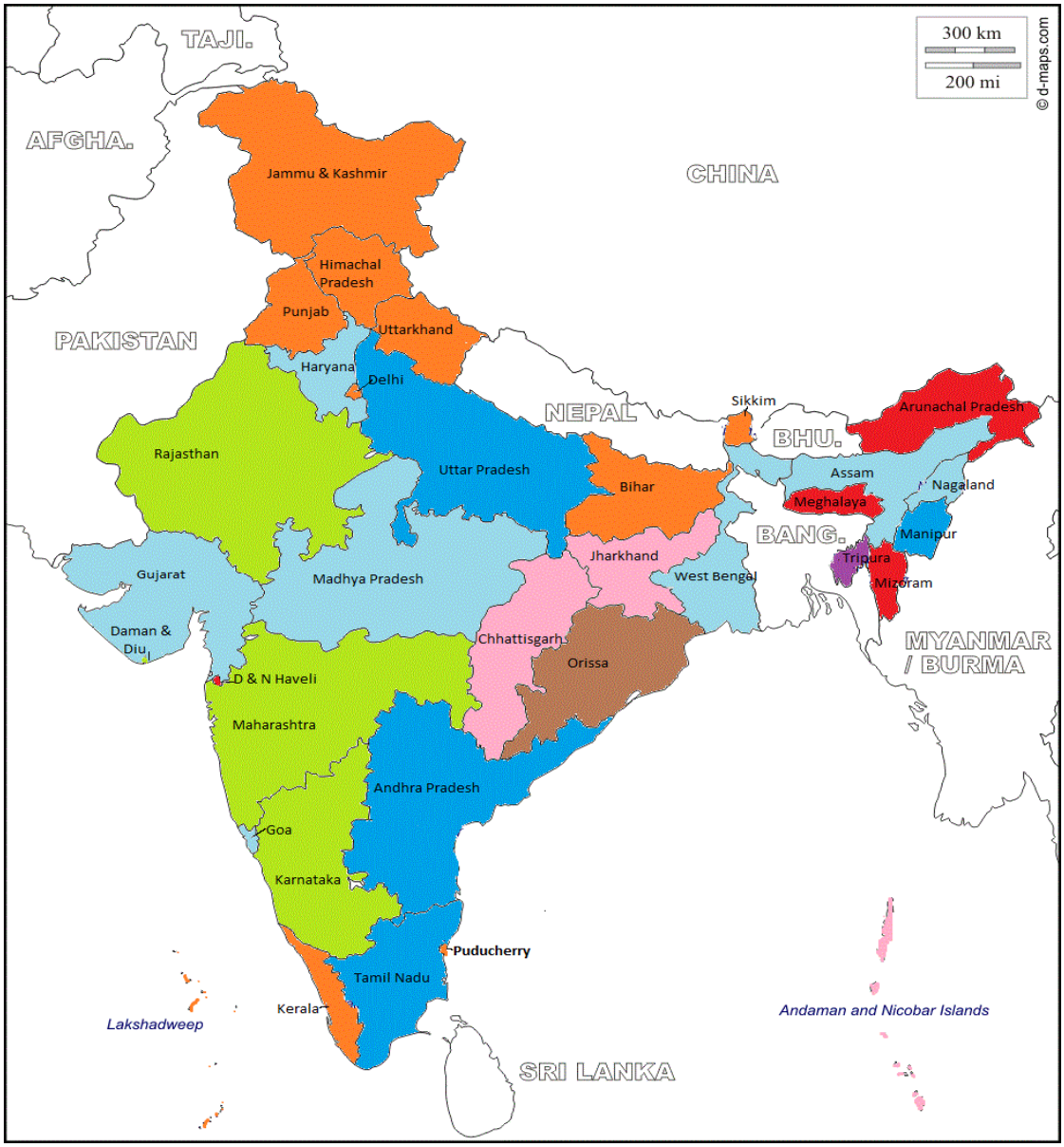
The results of one way ANOVA show that there was significant variation in mean prevalence rate of malaria between the states of India ($F=19.075$ and $p=0.000$). Further the Tukey HSD test was used to identify the homogenous subset of states and was arranged from lower to higher prevalence rate of malaria (Table 2).

First subgroup of homogeneous subsets of states of India generated by using SPSS consists of the states and union territories with low prevalence rate of malaria i.e., Delhi, Bihar, Himachal Pradesh, Kerala, Jammu & Kashmir, Lakshadweep, Sikkim, Punjab, Puducherry and Uttarakhand. Next homogenous subset consists of the states which have slightly high prevalence rate of malaria i.e. Chandigarh, Manipur, Tamil Nadu, Uttar Pradesh, Andhra Pradesh and third group which have next highest prevalence rate of malaria consists four states i.e. Karnataka, Rajasthan and Maharashtra and Daman & Diu. Next homogeneous subgroup consist seven

states i.e., West Bengal, Haryana, Gujarat, Madhya Pradesh, Assam, Nagaland and Goa which have moderate prevalence rate of malaria. Fifth and seventh homogeneous subgroup consist only one state each i.e. Tripura in fifth and Orissa in seventh subgroup. Sixth homogenous subgroup consists of only three states i.e. Chhattisgarh, Jharkhand and Andaman & Nicobar Islands which have third highest rate of prevalence. Finally the last homogenous subgroup of states which have highest rate of prevalence of malaria consists four states i.e. Mizoram, Dadar & Nagar Haveli, Arunachal Pradesh and Meghalaya. It has also been noted that rainfall is comparatively high in these above mentioned states with high prevalence of malaria. Substantiating evidence has been obtained by a study conducted by Karema et al. [13] in Rwanda in district hospitals where rainfall and temperature remained favourable for malaria transmission. Also the above states located next to the international borders with China in the north, Myanmar the east, Bangladesh in the southeast and Bhutan to the northwest. The entire population is largely classified as tribal with at least 230 ethnic groups, rich in culture heritage, fauna and flora and major river systems [14]. The situation of malaria epidemic in India is clearly shown in India map (Fig. 2).

Table 2. The homogeneous subsets generated by using Tukey HSD Post Hoc test

Stats	N	Subset for alpha = 0.05							
		1	2	3	4	5	6	7	8
Delhi	6	.0017							
Bihar	6	.0026							
Himachal Pradesh	6	.0028							
Kerala	6	.0057							
Jammu & Kashmir	6	.0057							
Lakshadweep	6	.0068							
Sikkim	6	.0081							
Punjab	6	.0091							
Puducherry	6	.0094							
Uttarakhand	6	.0146							
Chandigarh	6		.0251						
Manipur	6		.0263						
Tamil Nadu	6		.0271						
Uttar Pradesh	6		.0309						
Andhra Pradesh	6		.0319						
Karnataka	6			.0515					
Daman & Diu	6			.0601					
Rajasthan	6			.0664					
Maharashtra	6			.0747					
West Bengal	6				.0970				
Haryana	6				.1043				
Gujarat	6				.1093				
Madhya Pradesh	6				.1218				
Assam	6				.1893				
Nagaland	6				.2032				
Goa	6				.2171				
Tripura	6					.4977			
Chhattisgarh	6						.5382		
Jharkhand	6						.5551		
A & N Islands	6						.6142		
Orissa	6							.7997	
Mizoram	6								1.0481
D & N Haveli	6								1.1713
Arunachal Pradesh	6								1.3222
Meghalaya	6								1.4677
Sig.		.091	.062	.077	.056	.943	.067	.648	.368



- Mean prevalence rate of malaria between 0.002 to 0.020.
- Mean prevalence rate of malaria between 0.026 to 0.032.
- Mean prevalence rate of malaria between 0.052 to 0.075.
- Mean prevalence rate of malaria between 0.098 to 0.22.
- Mean prevalence rate of malaria 0.497.
- Mean prevalence rate of malaria between 0.53 to 0.62.
- Mean prevalence rate of malaria is 0.799.
- Mean prevalence rate of malaria between 0.10 to 1.5.

Fig. 2. Malaria epidemic situation in India

4. CONCLUSION

This study has explored the geographical patterns of transmissibility of malaria in India, using time series data, made available by reports of National Vector Borne Disease Control Programme (NVBDCP), Ministry of Health and Family Welfare, Government of India. The study indicates the rate of prevalence of malaria was decreasing during the study period. The result also reveals that there is significant difference between number of deaths and survival over a period of time.

Further we observed that there is significant difference between the transmissibility of prevalence rate of malaria across the geographical areas, even though the rate of prevalence of malaria shown decreasing trend over the study period. Finally the results of the study concluded that in four states viz. Mizoram, Dadar & Nagar Haveli, Arunachal Pradesh and Meghalaya are the highest rate prevalence of malaria as compared to other states of India.

5. RECOMMENDATIONS

Rainfall in these states is comparatively more than other states of India which provides an ideal ground for breeding places for anopheline mosquito; hence programme implementation should give more focus to control the transmissibility malaria in these states. High risk groups have to utilize the personal prophylactic measures to avoid mosquito bite and community based action programmes also essential to stop the vector breeding sources in the surroundings.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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